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Design and Assessment of Deep and Active Learning in Science, Technology, Engineering, and Mathematics (STEM) Education

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Introduction of Presenters

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Collaborative Research: Open Access Blended Learning Modules for Teaching Laboratory Methods: Developing Scientific Skills for Undergraduates

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Outline

Scholarly Significance

Deep Learning & Student-centered Learning

Instructional and Assessment Design in STEM

Overview and Scholarly Significance

- STEM in the U.S. context

- The need for design and assessment strategies that can
  - help create deep and active learning, creativity, critical thinking, learner autonomy and metacognition, and the ability to learn in this fast-changing society;
  - enable students to master the knowledge foundation of scientific concepts but also learn the ways of thinking as scientists design.

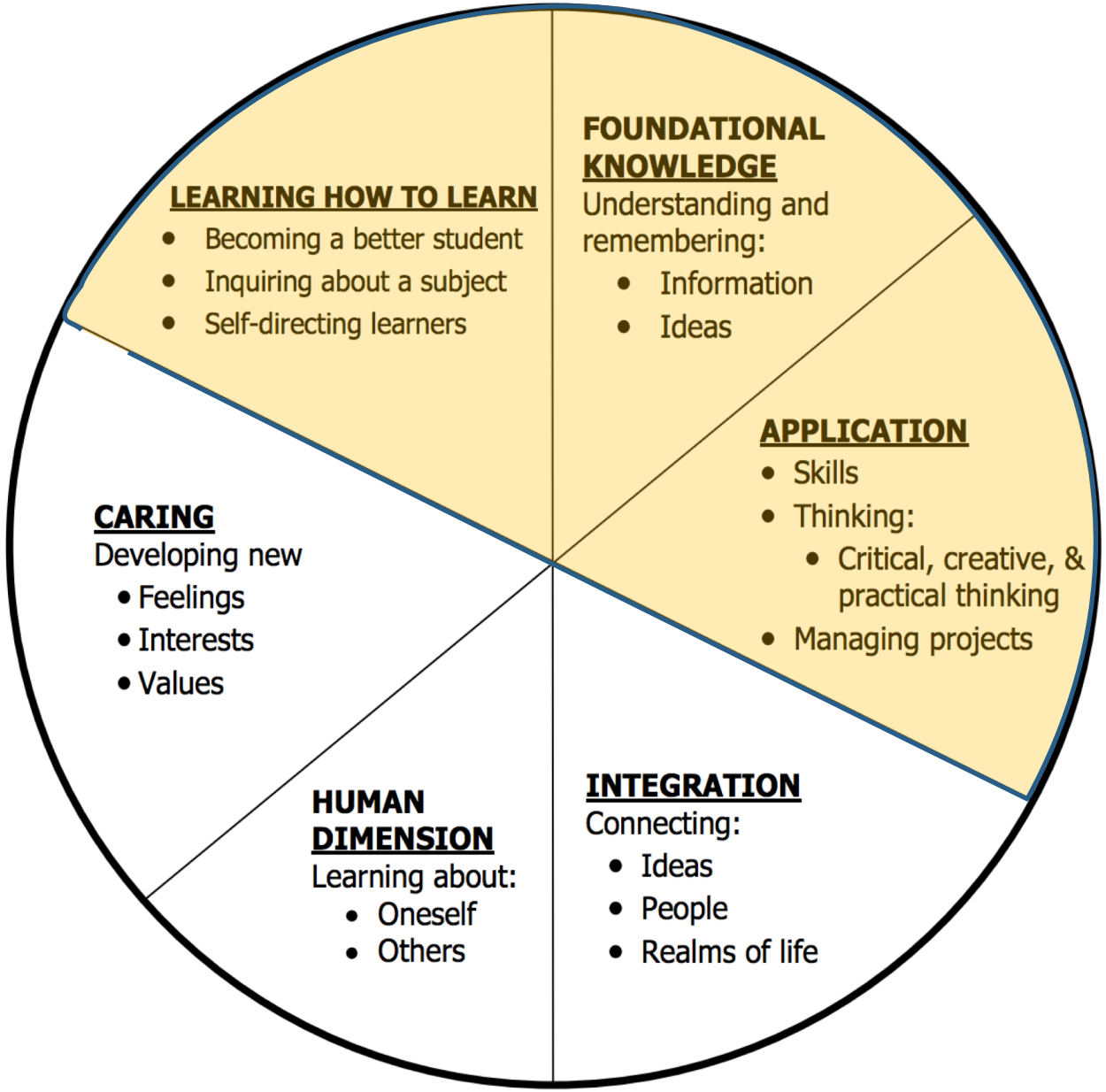
- Open Educational Resources (OER) and STEM education

“

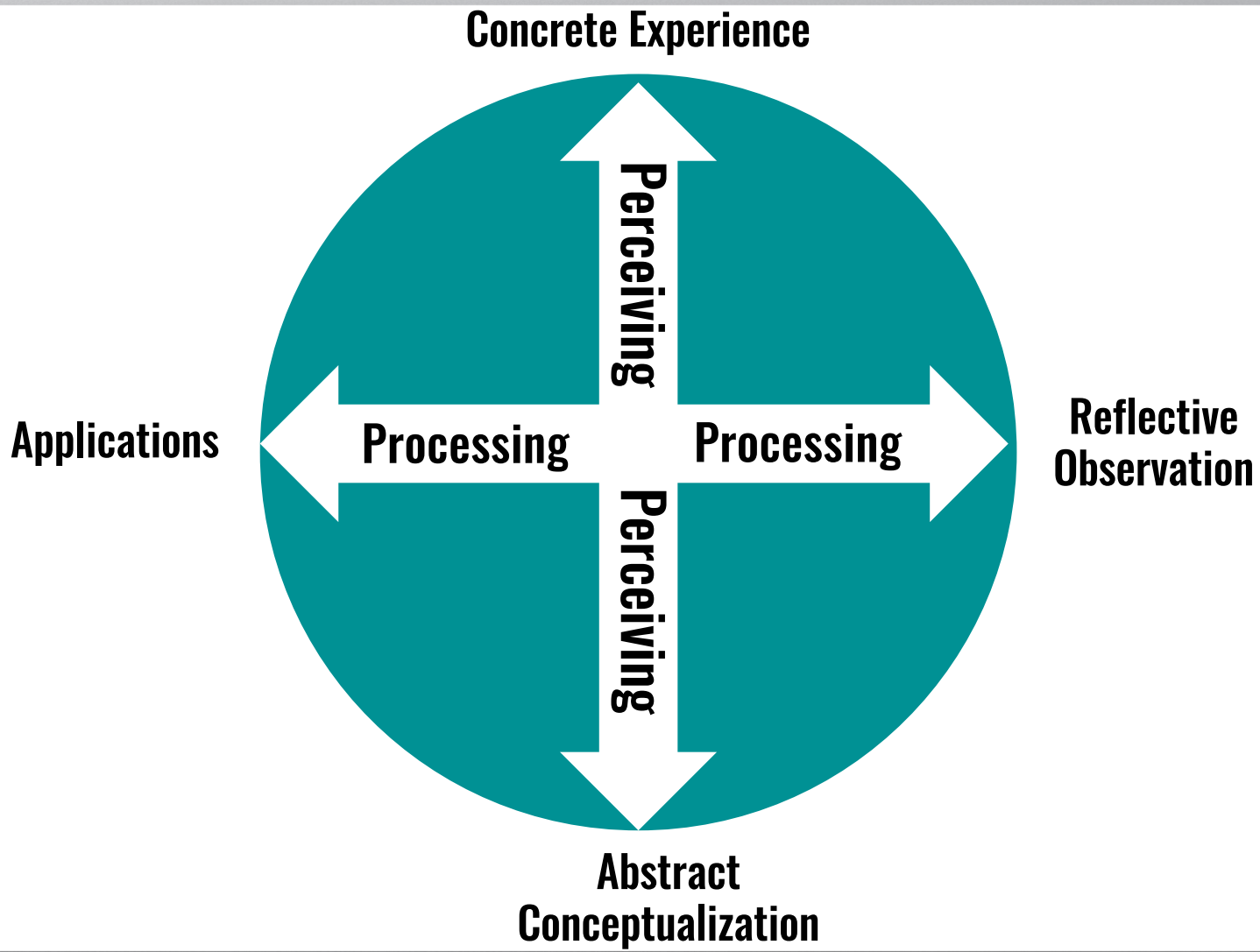
“In the **deep [learning] approach**, the intention to extract meaning produces active learning processes that involve relating ideas and looking for patterns and principles on the one hand, and using evidence and examining the logic of the argument on the other. The approach also involves monitoring the development of one’s own understanding”

(Entwistle, 2000, p. 3)

Taxonomy of Significant Learning



Fink，2013


Concrete Experience
Perceiving
Applications
Processing
Processing
Reflective Observation
Perceiving
Abstract Conceptualization

Kolb, D. A. (2000).

ID Strategies for Student-Centered Learning

- Flipped Classroom/Flipped Learning
- Problem-based Learning / Project-based Learning
- Process-Oriented Guided Inquiry Learning (POGIL)
- Team-based Learning
- PLTL

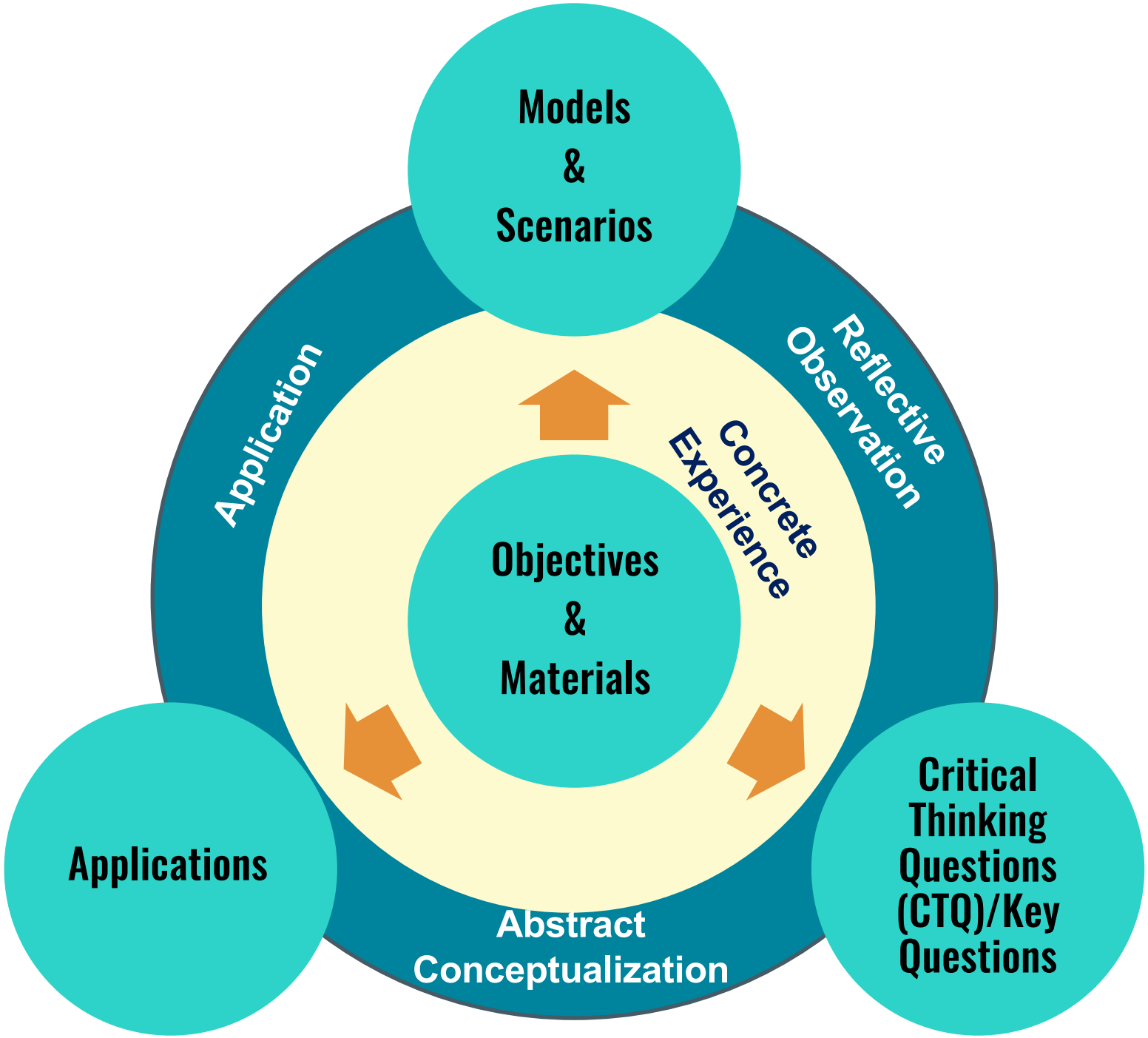
Design for STEM Learning

Image credit: Wikimedia Commons

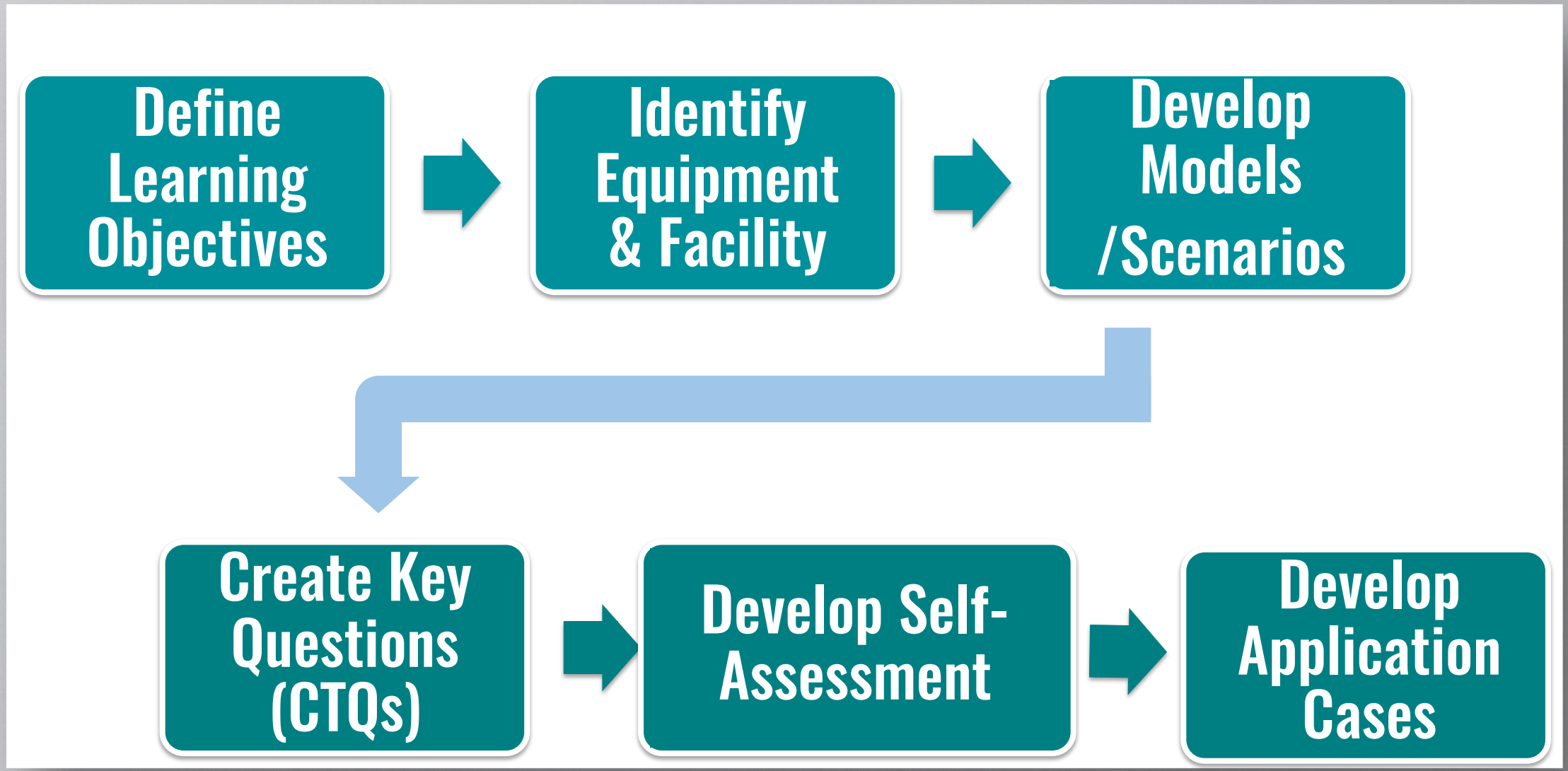
Process-Oriented Guided Inquiry Learning

- Selected ID Strategy for NSF Project

POGIL Components



POGIL Activity Design



Design-Scenario

“Thin sections are used for mineral identification, petrographic analysis to classify rocks, and textural analysis to describe how a rock is formed.” Now that you and your peer classmates were requested by a local mineral society to analyze a piece of chlorite schist.

Design-Content Presentation

https://youtu.be/Lm47uPCtYbs

Design-Key Questions

What are the core stages of preparing a thin section?

A power-driven, diamond impregnated lapping wheel is used for

- **Cutting the original specimen**
- **Mounting the chip**
- **Cleaning the section with abrasive powder ****
- **Sliding labels**

Self-Assessment:

Interactive Video: https://www.playposit.com/play/589222

A hotspot sample:

https://h5p.org/node/70886

A self quiz sample:

https://h5p.org/node/70882

Procedure	Description	Redesign
Title	Label the activity	
Why	Explain the identify the reasons for learning	
Learning Objectives	**List what is to be learned**	
Success Criteria	Determine the desired outcomes and abilities that will be used to measure performance and achievement	
Prerequisite	Identify the prior skills and knowledge that are needed	
Resources and Information	Provide information needed for the activity. Additional information can be provided to help students consolidate their learning after they have completed the “key questions.” List essential references related to the activity	
Glossary	Provide key terminology	
Plan and/or Tasks	**List the plan and/or tasks for meeting the learning objectives**	
Key Questions	**Pose questions that guide the execution of the plan and/or tasks, the exploration of the model, and processing of the information and resources in order to stimulate thought, introduce or form concepts, and construct understanding**	
Skill Exercises	Apply the new knowledge in simple situations and familiar contexts	
Problems	**Use the knowledge in new or real-world contexts requiring transference, synthesis, and integration of concepts**	
Self Assessment	**Have students identify what has been done well and develop strategies for improvement**	

Reference: Hanson, D. M. (2005). Designing process-oriented guided-inquiry activities. Faculty Guidebook-A Comprehensive Tool for Improving Faculty Performance. 2nd ed. Pacific Crest.

Assessment Design for STEM Learning

- Instruments - MLLI & Science Competency
- Observation
- Student Research Papers
- Rubric

Assessment of STEM Learning - Observation

Critical Thinking Rubric for Scoring Scien

	Exceeds Standards - 4
Presents required content in Introduction (Note: This category counts 3X of points as other categories, e.g. Exceeds Standards equals 3x4=12.)	Accurately and thorough presents required conten ***Introduction***, including scientific principles, hist how the instrument work description of instrumen
States Problem or Hypotheses	The purpose/hypotheses clearly stated and are dir connected to the context specific project.
Identifies Methods	Accurately and complete identifies instrumentatio running conditions, inclu the ***methods*** used to prep samples when needed, su Thin Section.
Presents Results	All data is recorded and organized in a clear man with labelled graphs, tab scanned images, and

Please indicate your agreement with each of the following statement by selecting ONE option.

When performing experiments in my geoscience laboratory course this semester, I expect...

	Strongly Disagree (0%)	Disagree (25%)	Neutral (50%)	Agree (75%)	Strongly Agree (100%)
to learn laboratory skills that will be useful in my life.	○	○	○	○	○
to worry about finishing on time.	○	○	○	○	○
to make decisions about what data to collect.	○	○	○	○	○
to feel unsure about the purpose of the procedures.	○	○	○	○	○
to experience moments of insight.	○	○	○	○	○

When performing experiments in my geoscience laboratory course this semester, I expect...

COLLABORATIVE RESEARCH:
Open Access Blended Learning Models for Teaching Laboratory Methods: Developing Scientific Skills for Undergraduates

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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